1.2 Features and benefits

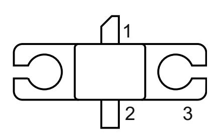
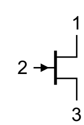
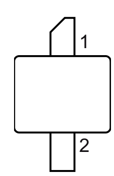
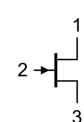
- Frequency of operation is from DC to 6.0 GHz
- 10 W general purpose broadband RF Power GaN HEMT
- Excellent ruggedness (VSWR = 10 : 1)
- High voltage operation (50 V)
- Thermally enhanced package

1.3 Applications

- Commercial wireless infrastructure (cellular, WiMAX)
- Radar
- Broadband general purpose amplifier
- Public mobile radios
- Industrial, scientific, medical
- Jammers
- EMC testing
- Defense application

2. Pinning information

Table 3. Pinning

Pin	Description	Simplified outline	Graphic symbol
CLF1G0060-10 (SOT1227A)			
1	drain		 aaa-003693
2	gate		
3	source [1]		
CLF1G0060S-10 (SOT1227B)			
1	drain		 aaa-003693
2	gate		
3	source [1]		

[1] Connected to flange.

3. Ordering information

Table 4. Ordering information

Type number	Package		
	Name	Description	Version
CLF1G0060-10	-	flanged ceramic package; 2 mounting holes; 2 leads	SOT1227A
CLF1G0060S-10	-	earless flanged ceramic package; 2 leads	SOT1227B

4. Limiting values

Table 5. Limiting values
In accordance with the Absolute Maximum Rating System (IEC 60134).

Symbol	Parameter	Conditions	Min	Max	Unit
V_{DS}	drain-source voltage		-	150	V
V_{GS}	gate-source voltage		–8	+3	V
I_{GF}	forward gate current	external R_G = 5 Ω	-	3.7	mA
T_{stg}	storage temperature		–65	+150	°C
T_j	junction temperature	measured via IR scan	-	250	°C

5. Thermal characteristics

Table 6. Thermal characteristics

Symbol	Parameter	Conditions	Typ	Unit
$R_{th(j-c)}$	thermal resistance from junction to case	T_j = 200 °C [1]	4.6	K/W

[1] T_j is measured via IR scan with case temperature of 85 °C and power dissipation of 24 W.

6. Characteristics

Table 7. DC Characteristics
T_{case} = 25 °C; unless otherwise specified.

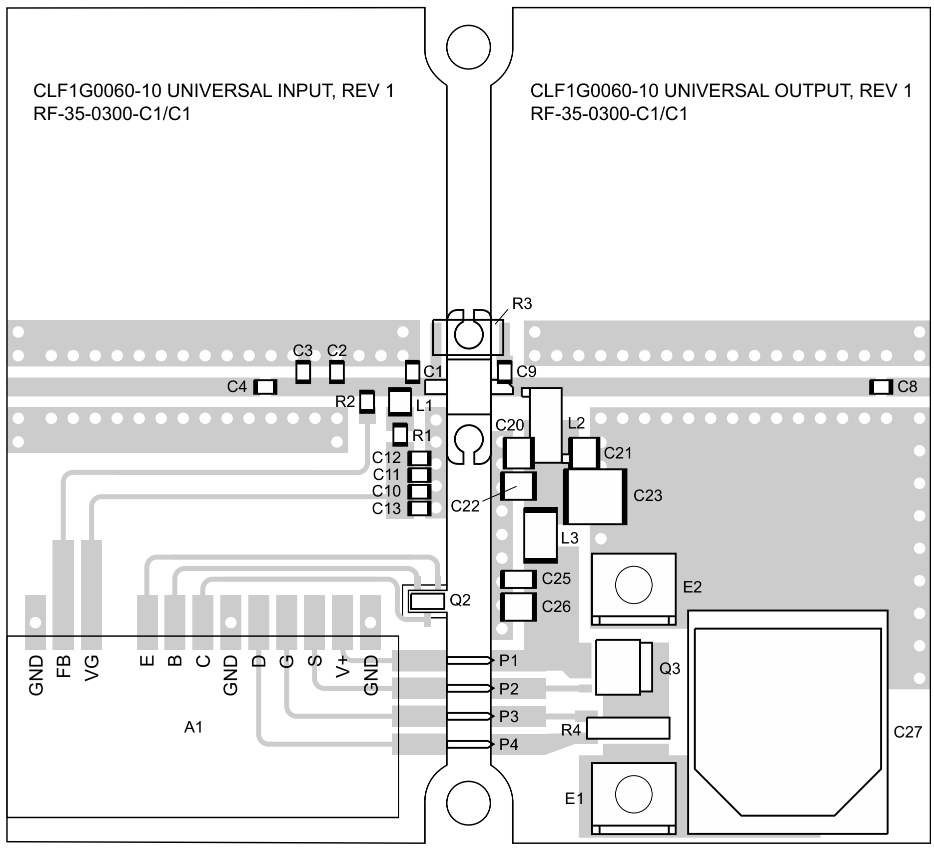
Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$V_{(BR)DSS}$	drain-source breakdown voltage	V_{GS} = –7 V; I_{DS} = 2.4 mA	150	-	-	V
$V_{GS(th)}$	gate-source threshold voltage	V_{DS} = 0.1 V; I_{DS} = 2.4 mA	–2.4	–2	–1.6	V
I_{DSX}	drain cut-off current	V_{DS} = 10 V; V_{GS} = 3 V	-	1.7	-	A
g_{fs}	forward transconductance	V_{DS} = 10 V; V_{GS} = 0 V	-	0.38	-	S

Table 8. RF Characteristics
Test signal: pulsed RF; f = 3 GHz; t_p = 100 μs; δ = 10 %; RF performance at V_{DS} = 50 V; I_{Dq} = 50 mA; T_{case} = 25 °C; unless otherwise specified in a class-AB production circuit.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
η_D	drain efficiency	P_L = 10 W	44	52	-	%
G_p	power gain	P_L = 10 W	13.5	16	-	dB
RL_{in}	input return loss	P_L = 10 W	-	–10	-	dB
$P_{droop(pulse)}$	pulse droop power	P_L = 10 W	-	0.04	-	dB
t_r	rise time	P_L = 10 W	-	5	-	ns
t_f	fall time	P_L = 10 W	-	5	-	ns

7. Application information

7.1 Demo circuit



Printed-Circuit Board (PCB) material: Taconic RF35, ε_r = 3.5, thickness 30 mils, 1 oz copper on each side.

See Table 9 for list of components.

Fig 1. The broadband amplifier (500 MHz to 2500 MHz) demo circuit outline

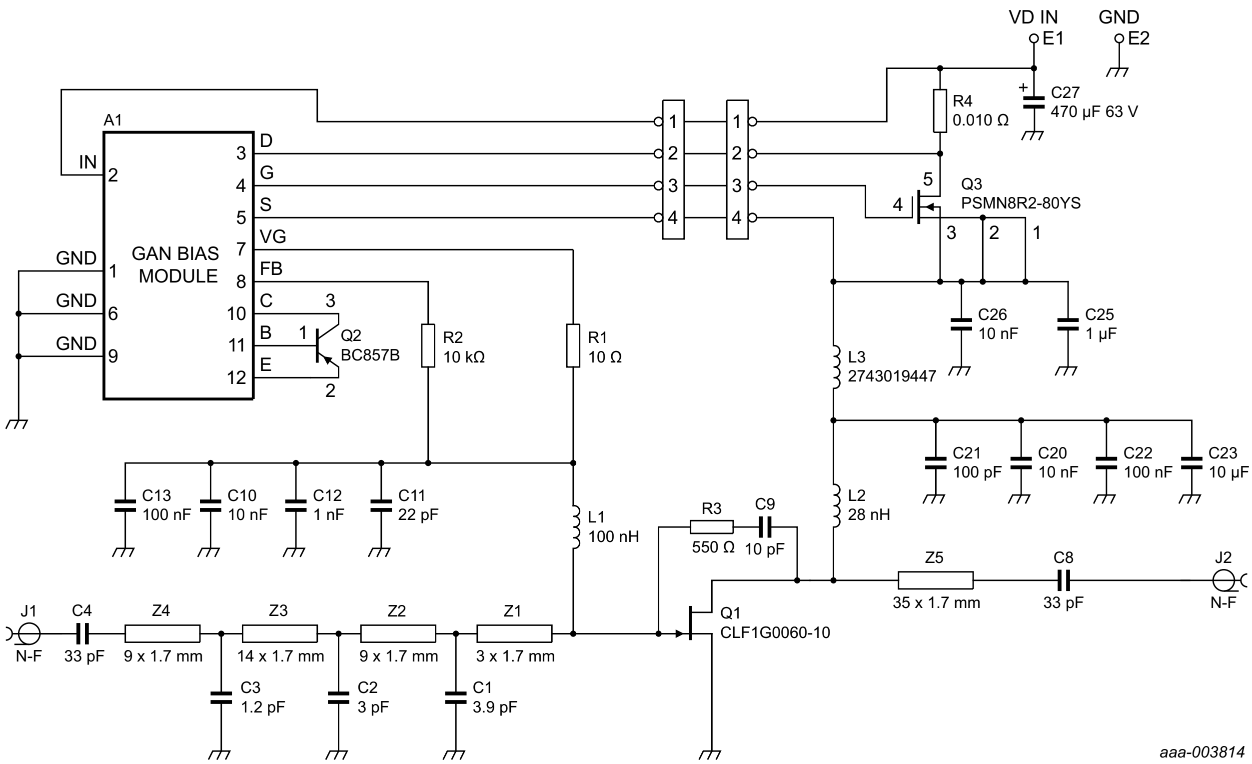
Table 9. List of components

See Figure 1.

Component	Description	Value	Remarks
A1	GaN bias module v2	-	Ampleon
C1	multilayer ceramic chip capacitor	3.9 pF	ATC 600F
C2	multilayer ceramic chip capacitor	3.0 pF	ATC 600F
C3	multilayer ceramic chip capacitor	1.2 pF	ATC 600F
C4, C8	multilayer ceramic chip capacitor	33 pF	ATC 600F
C9	multilayer ceramic chip capacitor	10 pF	ATC 600F
C10	electrolytic capacitor	10 nF, 50 V	SMD 0805
C11	electrolytic capacitor	22 nF, 100 V	SMD 0805
C12	electrolytic capacitor	1 nF, 100 V	SMD 0805

Table 9. List of components *...continued*
See Figure 1.

Component	Description	Value	Remarks
C13	electrolytic capacitor	100 nF, 50 V	SMD 0805
C20	multilayer ceramic chip capacitor	1 nF	ATC 700B
C21	multilayer ceramic chip capacitor	100 pF	ATC 700B
C22, C26	electrolytic capacitor	10 nF, 200 V	SMD 1210
C23	electrolytic capacitor	10 μF, 100 V	SMD 2220
C25	electrolytic capacitor	1 μF, 100 V	SMD 1206
C27	electrolytic capacitor	470 μF, 63 V	Panasonic EEE-TK1J471AM
E1, E2	drain voltage connection	-	
J1	RF in connector	-	
J2	RF out connector	-	
L1	inductor	100 nH	Coilcraft 0805CS-101XJL
L2	inductor	28 nH	Coilcraft B08TJL
L3	ferrite bead	5 A	Fair-Rite 2743019447
P1, P2, P3, P4	1 row, 4-way vertical DC connector header	-	
Q1	transistor	-	CLF1G0060-10
Q2	transistor	-	NXP BC857B
Q3	transistor	-	NXP PSMN8R2-80YS
R1	resistor	10.0 Ω	Generic
R2	resistor	10.0 kΩ	Generic
R3	resistor	550 Ω	Generic
R4	resistor	0.01 Ω	Susumu RL7520WT-R010-F



See Table 9 for a list of components.

Fig 2. The broadband amplifier (500 MHz to 2500 MHz) demo circuit schematic

7.2 Application test results

Table 10. CW and pulsed RF application information

Typical RF performance at T_{case} = 25 °C; I_{Dq} = 40 mA; V_{DS} = 50 V in a class-AB broadband demo board.

Test signal	f	P_L	G_p	η_D
	(MHz)	(W)	(dB)	(%)
1-Tone CW	200	10	17.7	42.6
	500	10	16.7	46.6
	1000	10	15	38.7
	1500	10	14.3	32.6
	2000	10	14.2	32.6
1-Tone pulsed [1]	200	10	18.8	44
	500	10	17.8	48.2
	1000	10	16.8	39
	1500	10	16.7	33.9
	2000	10	17	33.2

[1] Pulsed RF; t_p = 15 μs; δ = 10 %.

Table 11. 2-Tone CW application information

Typical 2-Tone performance at T_{case} = 25 °C; I_{Dq} = 40 mA; V_{DS} = 50 V in a class-AB broadband demo board.

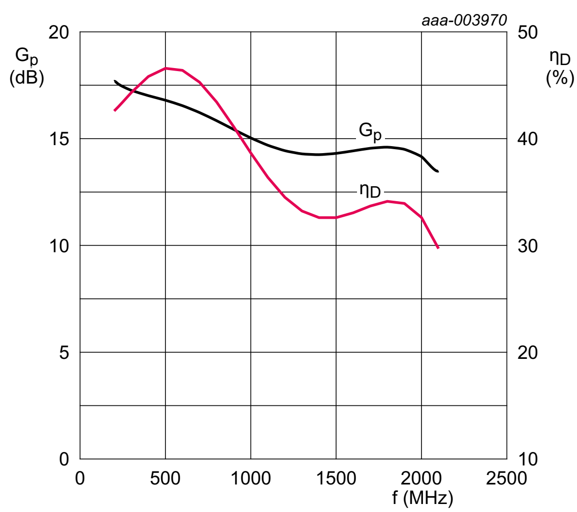
Test signal	f	$P_{L(PEP)}$	IMD3
	(MHz)	(W)	(dBc)
2-Tone CW [1]	500	5	–47.4
	1000	5	–48.7
	1500	5	–44.7
	2000	5	–39.2
	2500	5	–40.4

[1] 2-Tone CW; Δf = 1 MHz.

7.3 Graphical data

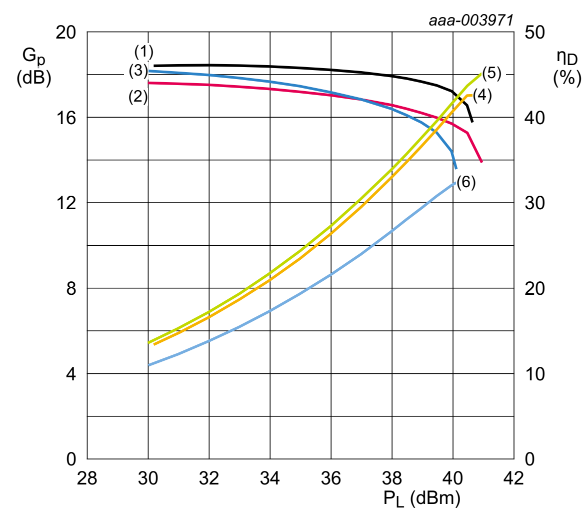
The following figures are measured in a broadband amplifier demo board from 500 MHz to 2500 MHz.

7.3.1 1-Tone CW RF performance



V_{DS} = 50 V; I_{Dq} = 40 mA; P_L = 10 W.

Fig 3. Power gain and drain efficiency as function of frequency; typical values

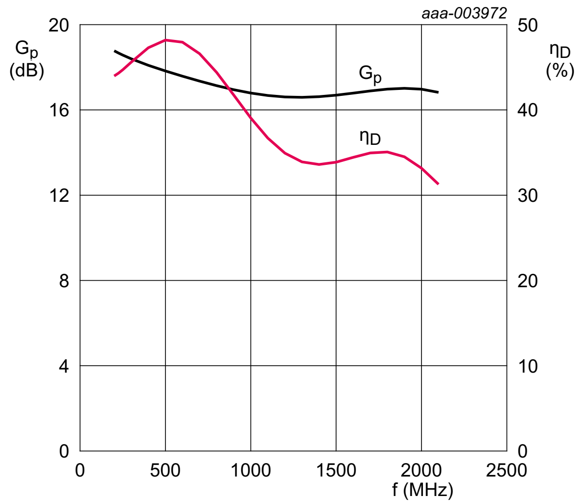


V_{DS} = 50 V; I_{Dq} = 40 mA.

(1) G_p at f = 200 MHz
(2) G_p at f = 1000 MHz
(3) G_p at f = 2000 MHz
(4) η_D at f = 200 MHz
(5) η_D at f = 1000 MHz
(6) η_D at f = 2000 MHz

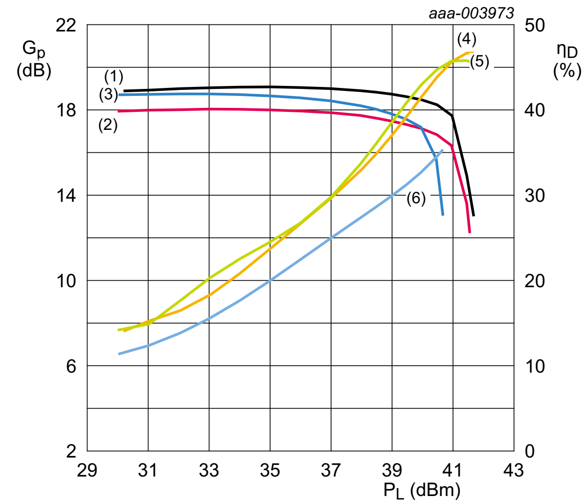
Fig 4. Power gain and drain efficiency as function of output power; typical values

7.3.2 1-Tone pulsed RF performance



V_{DS} = 50 V; I_{Dq} = 40 mA; P_L = 10 W; t_p = 15 μs; δ = 1 %.

Fig 5. Power gain and drain efficiency as function of frequency; typical values

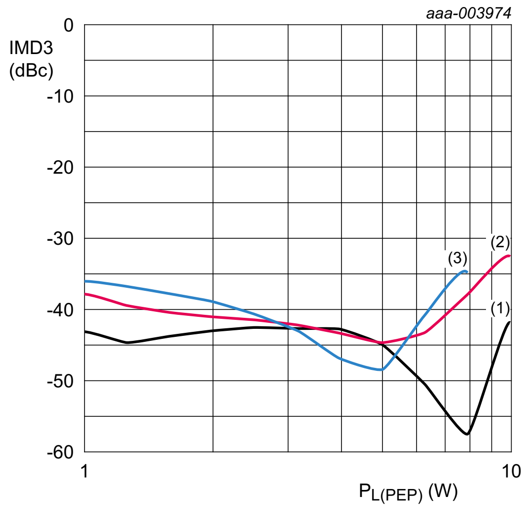


V_{DS} = 50 V; I_{Dq} = 40 mA; t_p = 15 μs; δ = 1 %.

(1) G_p at f = 200 MHz
(2) G_p at f = 1000 MHz
(3) G_p at f = 2000 MHz
(4) η_D at f = 200 MHz
(5) η_D at f = 1000 MHz
(6) η_D at f = 2000 MHz

Fig 6. Power gain and drain efficiency gain as function of output power; typical values

7.3.3 2-Tone CW performance



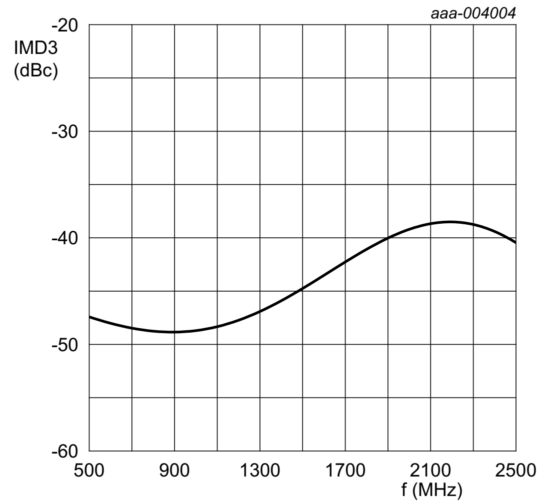
V_{DS} = 50 V; I_{Dq} = 50 mA; Δf = 1 MHz.

(1) f = 300 MHz

(2) f = 1100 MHz

(3) f = 2000 MHz

Fig 7. Third-order intermodulation distortion as a function of peak envelope power; typical values



V_{DS} = 50 V; I_{Dq} = 150 mA; $P_{L(PEP)}$ =10 W.

Fig 8. Third-order intermodulation distortion as a function of frequency; typical values

7.3.4 Bias module

The bias module information for the GaN HEMT amplifier is described in application note *AN11130*.

8. Test information

8.1 Ruggedness in class-AB operation

The CLF1G0060-10 and CLF1G0060S-10 are capable of withstanding a load mismatch corresponding to VSWR = 10 : 1 through all phases under the following conditions: V_{DS} = 50 V; P_L = 10 W (pulsed RF), f = 3000 MHz.

8.2 Load pull impedance information

The measured load pull impedances are shown below. Impedance reference plane defined at device leads. Measurements performed with Ampleon test fixtures. Test temperature set at 25 °C with a pulsed CW signal; t_p = 100 μs; δ = 10 %; RF performance at V_{DS} = 50 V; I_{Dq} = 20 mA.

Table 12. Typical impedance
Typical values unless otherwise specified.

f	Z_S	Z_L (maximum $P_{L(M)}$)	Z_L (maximum η_D)
(MHz)	(Ω)	(Ω)	(Ω)
2500	4.7 – 3.8j	23.1 + 22.6j	12 + 28.4j
2700	4.5 – 6.3j	19.5 + 22.2j	9.1 + 25.1j
3300	6.6 – 14j	14 + 13.5j	7.9 + 18.6j
3500	6.5 – 18j	12.7 + 14.7j	7.5 + 15.6j
3700	8.1 – 22j	12.7 + 14.7j	6.7 + 14.6j
4000	8.3 – 32j	9.5 + 13.8j	6.5 + 13.8j

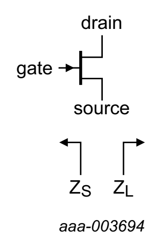


Fig 9. Definition of transistor impedance

Z_S is the measured source pull impedance presented to the device. Z_L is the measured load pull impedance presented to the device.

8.3 Packaged S-parameter data

Table 13. S-parameter
Small signal; V_{DS} *= 50 V;* I_{Dq} *= 20 mA;* $Z_S = Z_L = 50\ \Omega$.

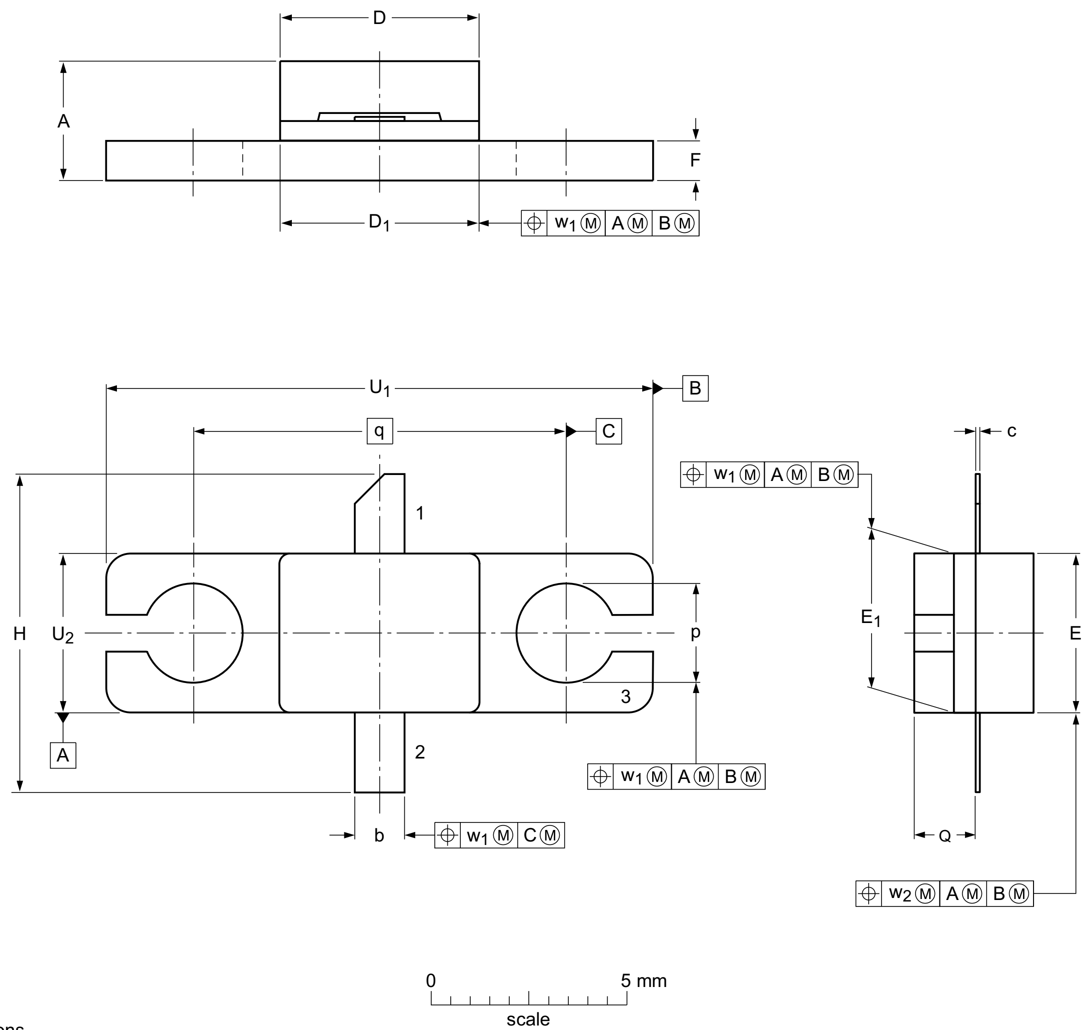
f (MHz)	S_{11}		S_{21}		S_{12}		S_{22}	
	Magnitude (ratio)	Angle (degree)	Magnitude (ratio)	Angle (degree)	Magnitude (ratio)	Angle (degree)	Magnitude (ratio)	Angle (degree)
100	0.99129	−23.269	21.314	164.59	0.0071276	75.423	0.95962	−10.001
200	0.96902	−44.968	19.981	150.22	0.013329	61.893	0.92382	−19.186
300	0.94116	−64.133	18.221	137.49	0.018152	50.009	0.87835	−27.146
400	0.91414	−80.511	16.383	126.5	0.021627	39.869	0.83352	−33.905
500	0.89101	−94.309	14.666	117.04	0.024008	31.278	0.79464	−39.708
600	0.87242	−105.92	13.145	108.84	0.025571	23.957	0.76322	−44.832
700	0.85792	−115.75	11.832	101.62	0.026538	17.641	0.73885	−49.499
800	0.84676	−124.16	10.706	95.167	0.027071	12.118	0.72048	−53.868
900	0.83822	−131.44	9.7421	89.316	0.027281	7.2229	0.70698	−58.039
1000	0.8317	−137.82	8.9136	83.937	0.027246	2.8351	0.69734	−62.075
1100	0.82673	−143.48	8.1977	78.936	0.027018	−1.1346	0.69074	−66.012
1200	0.82294	−148.57	7.5751	74.24	0.026636	−4.751	0.68654	−69.873
1300	0.82008	−153.2	7.0302	69.796	0.026128	−8.0607	0.68423	−73.666
1400	0.81793	−157.44	6.5504	65.559	0.025514	−11.096	0.6834	−77.399
1500	0.81633	−161.37	6.1253	61.499	0.024809	−13.878	0.68374	−81.073
1600	0.81517	−165.04	5.7467	57.588	0.024028	−16.42	0.68499	−84.69
1700	0.81435	−168.5	5.4078	53.806	0.023179	−18.725	0.68697	−88.25
1800	0.81379	−171.78	5.103	50.136	0.022272	−20.79	0.68951	−91.753
1900	0.81344	−174.91	4.8277	46.564	0.021316	−22.605	0.69248	−95.199
2000	0.81325	−177.92	4.5781	43.078	0.020316	−24.15	0.69577	−98.59
2100	0.81317	179.17	4.351	39.668	0.019282	−25.396	0.6993	−101.92
2200	0.81318	176.35	4.1437	36.326	0.018222	−26.304	0.70298	−105.21
2300	0.81325	173.6	3.954	33.045	0.017143	−26.82	0.70677	−108.43
2400	0.81336	170.91	3.7798	29.818	0.016058	−26.873	0.71061	−111.61
2500	0.8135	168.27	3.6196	26.639	0.014978	−26.372	0.71447	−114.74
2600	0.81364	165.66	3.4718	23.502	0.013923	−25.202	0.7183	−117.83
2700	0.81378	163.09	3.3353	20.404	0.012912	−23.223	0.72209	−120.87
2800	0.8139	160.54	3.2089	17.34	0.011978	−20.279	0.72581	−123.87
2900	0.81401	158	3.0917	14.305	0.011158	−16.219	0.72943	−126.83
3000	0.81409	155.48	2.9828	11.296	0.0105	−10.954	0.73296	−129.76
3100	0.81414	152.96	2.8815	8.3092	0.010059	−4.5429	0.73637	−132.66
3200	0.81416	150.44	2.7871	5.341	0.00989	2.7229	0.73966	−135.53
3300	0.81415	147.91	2.6991	2.3882	0.010031	10.309	0.74282	−138.37
3400	0.8141	145.38	2.6169	−0.5524	0.010495	17.578	0.74585	−141.19
3500	0.81402	142.83	2.5399	−3.4839	0.011266	23.999	0.74874	−144
3600	0.81392	140.27	2.4679	−6.4092	0.012313	29.286	0.75149	−146.78
3700	0.81378	137.69	2.4004	−9.3313	0.013594	33.387	0.7541	−149.56

Table 13. S-parameter *...continued*
Small signal; V_{DS} = 50 V; I_{Dq} = 20 mA; $Z_S = Z_L = 50\ \Omega$.

f (MHz)	S11		S21		S12		S22	
	Magnitude (ratio)	Angle (degree)	Magnitude (ratio)	Angle (degree)	Magnitude (ratio)	Angle (degree)	Magnitude (ratio)	Angle (degree)
3800	0.81362	135.09	2.337	−12.253	0.015073	36.394	0.75657	−152.33
3900	0.81344	132.46	2.2775	−15.177	0.016718	38.458	0.75891	−155.09
4000	0.81325	129.8	2.2215	−18.106	0.018506	39.738	0.76111	−157.86
4100	0.81305	127.11	2.1687	−21.043	0.020419	40.375	0.76318	−160.63
4200	0.81286	124.39	2.119	−23.991	0.022446	40.485	0.76513	−163.4
4300	0.81267	121.64	2.072	−26.952	0.024575	40.163	0.76694	−166.19
4400	0.8125	118.84	2.0276	−29.928	0.026802	39.483	0.76865	−168.99
4500	0.81236	116.01	1.9856	−32.922	0.029121	38.504	0.77023	−171.81
4600	0.81226	113.13	1.9457	−35.937	0.031528	37.269	0.77171	−174.65
4700	0.81221	110.22	1.9078	−38.976	0.034021	35.816	0.77309	−177.52
4800	0.81222	107.25	1.8718	−42.04	0.036598	34.172	0.77438	179.58
4900	0.81231	104.25	1.8374	−45.132	0.039257	32.359	0.77558	176.64
5000	0.81249	101.19	1.8045	−48.254	0.041996	30.394	0.77669	173.66
5100	0.81278	98.091	1.7729	−51.409	0.044813	28.293	0.77774	170.63
5200	0.81319	94.941	1.7426	−54.599	0.047706	26.065	0.77873	167.55
5300	0.81374	91.743	1.7133	−57.826	0.050674	23.72	0.77966	164.42
5400	0.81444	88.496	1.685	−61.092	0.053712	21.266	0.78055	161.22
5500	0.81531	85.202	1.6575	−64.4	0.056818	18.706	0.7814	157.96
5600	0.81637	81.859	1.6307	−67.75	0.059987	16.048	0.78224	154.63
5700	0.81764	78.47	1.6044	−71.146	0.063214	13.293	0.78307	151.22
5800	0.81912	75.035	1.5786	−74.588	0.066493	10.446	0.78391	147.73
5900	0.82083	71.556	1.5531	−78.079	0.069817	7.508	0.78477	144.15
6000	0.82279	68.034	1.5277	−81.619	0.073177	4.4824	0.78566	140.48

9. Package outline

Flanged ceramic package; 2 mounting holes; 2 leads **SOT1227A**



Dimensions

Unit(1)		A	b	c	D	D_1	E	E_1	F	H	p	Q	q	U_1	U_2	w_1	w_2
mm	max	3.68	1.40	0.15	5.18	5.21	4.17	4.19	1.14	8.64	2.67	1.70		14.10	4.19		
	nom												9.53			0.25	0.380
	min	2.84	1.14	0.08	4.98	4.95	3.96	3.94	0.89	7.62	2.41	1.45		13.84	3.94		
inches	max	0.145	0.055	0.006	0.204	0.205	0.164	0.165	0.045	0.340	0.105	0.067		0.555	0.165		
	nom												0.375			0.01	0.015
	min	0.112	0.045	0.003	0.196	0.195	0.156	0.155	0.035	0.300	0.095	0.057		0.545	0.155		

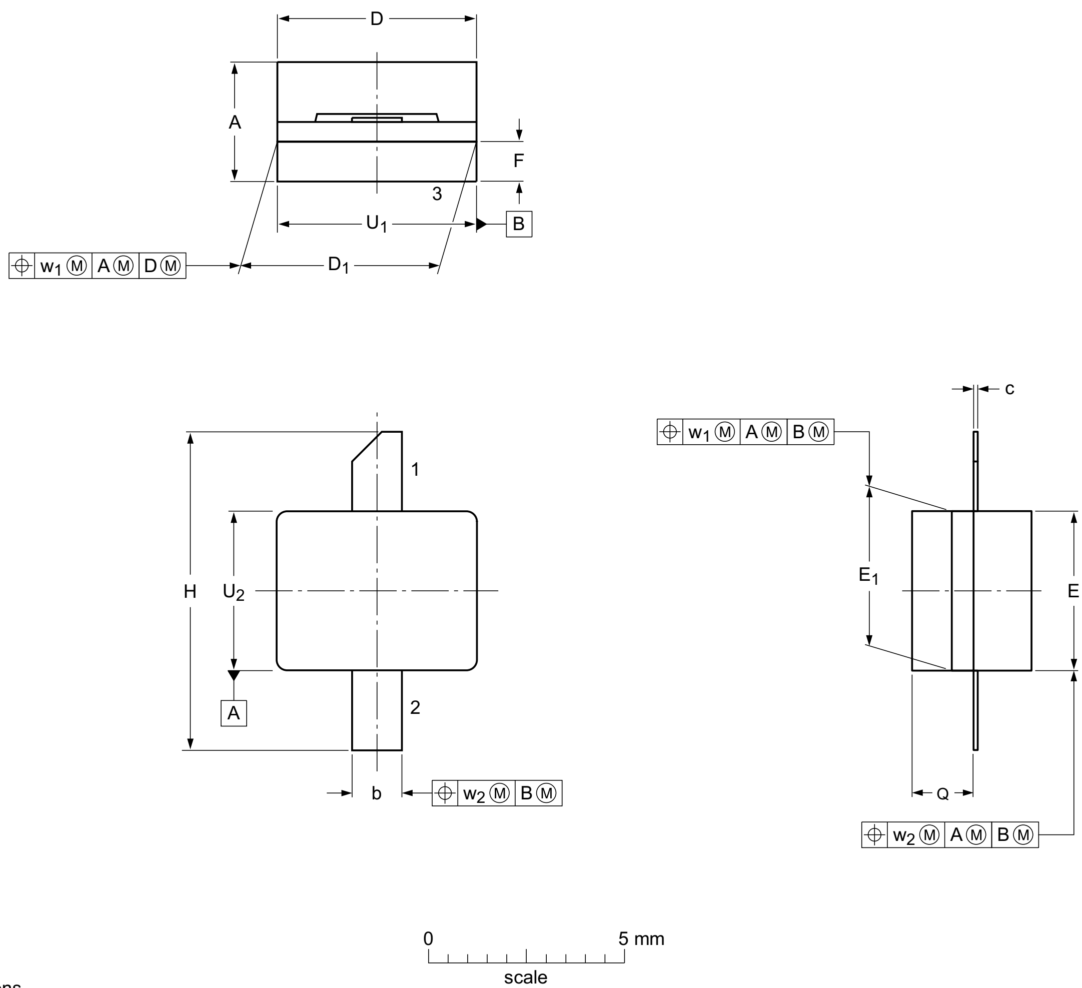
Note
1. Millimeter dimensions are derived from the original inch dimensions.

sot1227a_po

Outline version	References				European projection	Issue date
	IEC	JEDEC	JEITA			
SOT1227A						~~12-06-08~~ 13-10-14

Fig 10. Package outline SOT1227A

Earless Flanged ceramic package; 2 leads SOT1227B



Dimensions

Unit(1)		A	b	c	D	D_1	E	E_1	F	H	Q	U_1	U_2	w_1	w_2
mm	max	3.68	1.40	0.15	5.18	5.21	4.17	4.19	1.07	8.64	1.70	5.21	4.19	0.25	0.380
	nom														
	min	2.84	1.14	0.08	4.98	4.95	3.96	3.94	0.97	7.62	1.45	4.95	3.94		
inches	max	0.145	0.055	0.006	0.204	0.205	0.164	0.165	0.042	0.340	0.067	0.205	0.165	0.01	0.015
	nom														
	min	0.112	0.045	0.003	0.196	0.195	0.156	0.155	0.038	0.300	0.057	0.195	0.155		

Note

1. Millimeter dimensions are derived from the original inch dimensions.

sot1227b_po

Outline version	References				European projection	Issue date
	IEC	JEDEC	JEITA			
SOT1227B						~~12-06-08~~ 13-10-15

Fig 11. Package outline SOT1227B

10. Handling information

10.1 ESD Sensitivity

Table 14. ESD sensitivity

ESD model	Class
Human Body Model (HBM); According JEDEC standard JESD22-A114F	1B [1]

[1] Classification 1B is granted to any part that passes after exposure to an ESD pulse of 500 V, but fails after exposure to an ESD pulse of 1000 V.

11. Abbreviations

Table 15. Abbreviations

Acronym	Description
CW	Continuous Wave
EMC	ElectroMagnetic Compatibility
ESD	ElectroStatic Discharge
GaN	Gallium Nitride
HEMT	High Electron Mobility Transistor
SMD	Surface Mounted Device
VSWR	Voltage Standing-Wave Ratio
WiMAX	Worldwide Interoperability for Microwave Access

12. Revision history

Table 16. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
CLF1G0060-10_1G0060S-10 v.5	20160218	Product data sheet	-	CLF1G0060-10_1G0060S-10#4
Modifications:	• Table 8 on page 3: table updated • Section 8.1 on page 9: section updated • Figure 10 on page 13: figure updated • Figure 11 on page 14: figure updated			
CLF1G0060-10_1G0060S-10#4	20150901	Objective data sheet	-	CLF1G0060-10_1G0060S-10 v.3
CLF1G0060-10_1G0060S-10 v.3	20130530	Objective data sheet	-	CLF1G0060-10_1G0060S-10 v.2
CLF1G0060-10_1G0060S-10 v.2	20130129	Objective data sheet	-	CLF1G0060-10_1G0060S-10 v.1
CLF1G0060-10_1G0060S-10 v.1	20121008	Objective data sheet	-	-

13. Legal information

13.1 Data sheet status

Document status[1][2]	Product status[3]	Definition
Objective [short] data sheet	Development	This document contains data from the objective specification for product development.
Preliminary [short] data sheet	Qualification	This document contains data from the preliminary specification.
Product [short] data sheet	Production	This document contains the product specification.

[1] Please consult the most recently issued document before initiating or completing a design.

[2] The term 'short data sheet' is explained in section "Definitions".

[3] The product status of device(s) described in this document may have changed since this document was published and may differ in case of multiple devices. The latest product status information is available on the Internet at URL http://www.ampleon.com.

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15. Contents

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